RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS, Revision A

Meeting #17

Revisions to Appendix P, Section P.2
To complete TBDs in the Plenary Review copy of Appendix P

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SUMMARY
This working paper is submitted for the purpose of providing text, figures and tables which remained TBD, or that require revision in the version of Appendix P that was made available for RTCA SC-186 Plenary review on 20 December 2002. This document completes those TBD issues in section P.2 as provided by JHU-APL.

P.1 Filler

P.2 Performance Evaluation by APL

P.2.1 1090 Extended Squitter Detailed Simulation Features and Methodology

P.2.1.1 1090 ES Detailed Simulation Features

P.2.1.2 Calculation of the Performance Metrics

P.2.2 Receiver performance model

P.2.2.1 Background

P.2.2.2 Modifications to the Receiver Performance Model

Figure P-1: Comparison of "Mapped" APL Receiver Performance Model Prediction with FAATC Simulation Results

P.2.3 Los Angeles Basin 2020 (LA2020)

P.2.3.1 LA2020 Scenario Description

P.2.3.2 LA2020 Results and Analysis

Figure P-2: 95-95 State Vector Update Rate for A3-to-A3 Air-to-Air Reception in LA2020-[24k]

Figure P-3: 95-95 TSR Update Rate for A3-to-A3 Air-to-Air Reception in LA2020-[24k]

Figure P-4: 95-95 State Vector Update Rate for A2-to-A3 Air-to-Air Reception in LA2020-[24k]

Figure P-5: 95-95 TSR Rate for A2-to-A3 Air-to-Air Reception in LA2020-[24k]

Figure P-6: 95-95 State Vector Update Rate for A3-to-A3 Air-to-Air Reception in LA2020-[30k]

Figure P-7: 95-95 TSR Update Rate for A3-to-A3 Air-to-Air Reception in LA2020-[30k]

Figure P-8: 95-95 State Vector Update Rate for A2-to-A3 Air-to-Air Reception in LA2020-[30k]

Figure P-9: 95-95 TSR Update Rate for A2-to-A3 Air-to-Air Reception in LA2020-[30k]

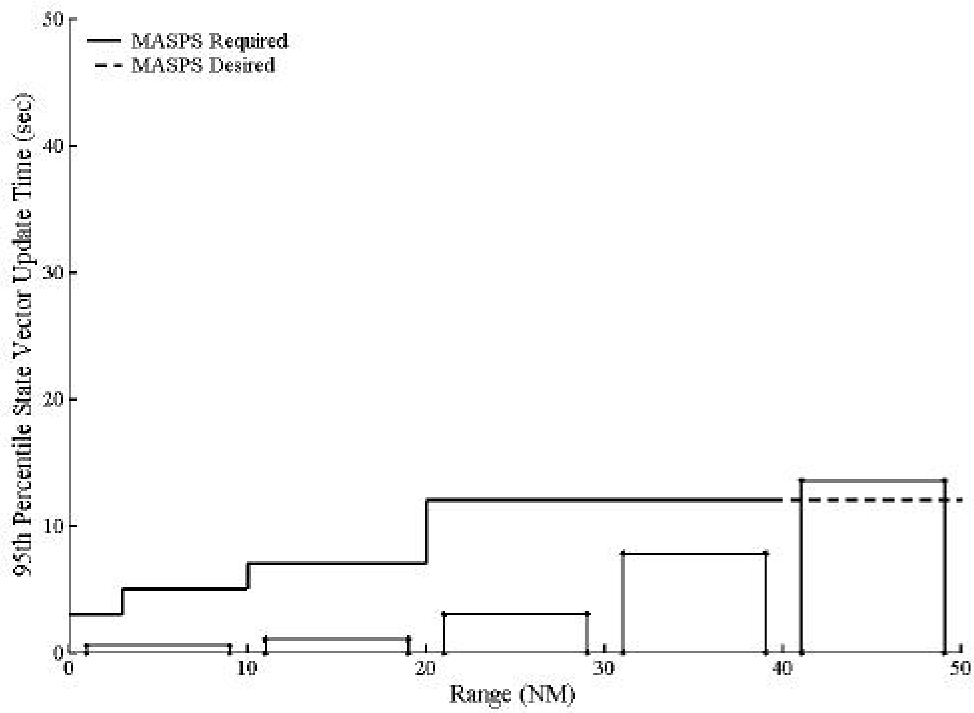

Figure P-10: 95-95 State Vector Update Rate for A3-to-A2 Air-to-Air Reception in LA2020-[24k]

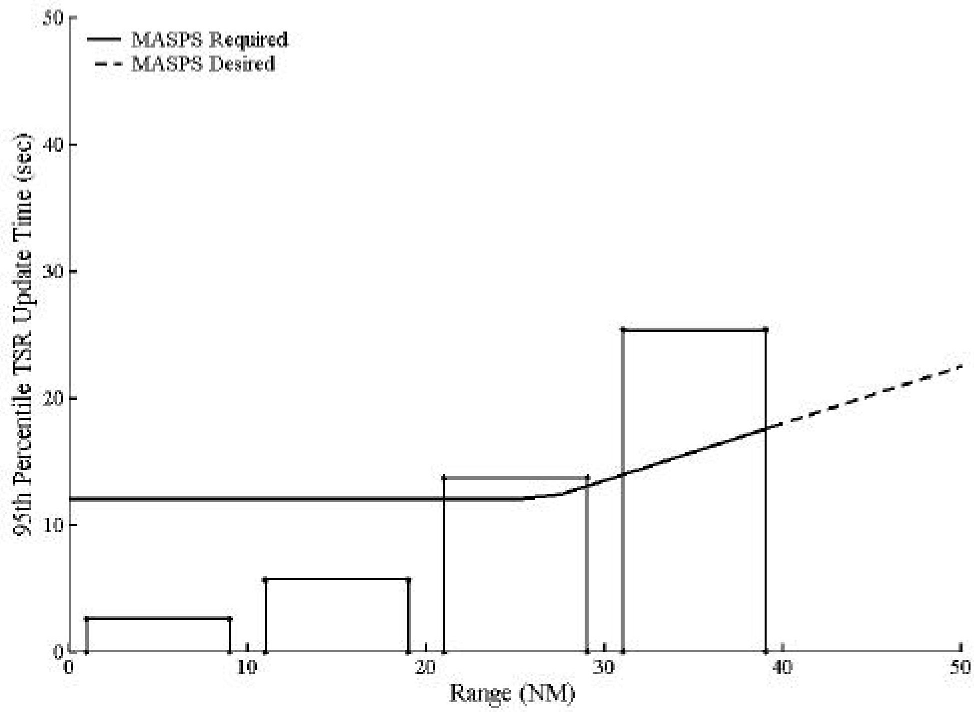

Figure P-11: 95-95 TSR Rate for A3-to-A2 Air-to-Air Reception in LA2020-[24k]

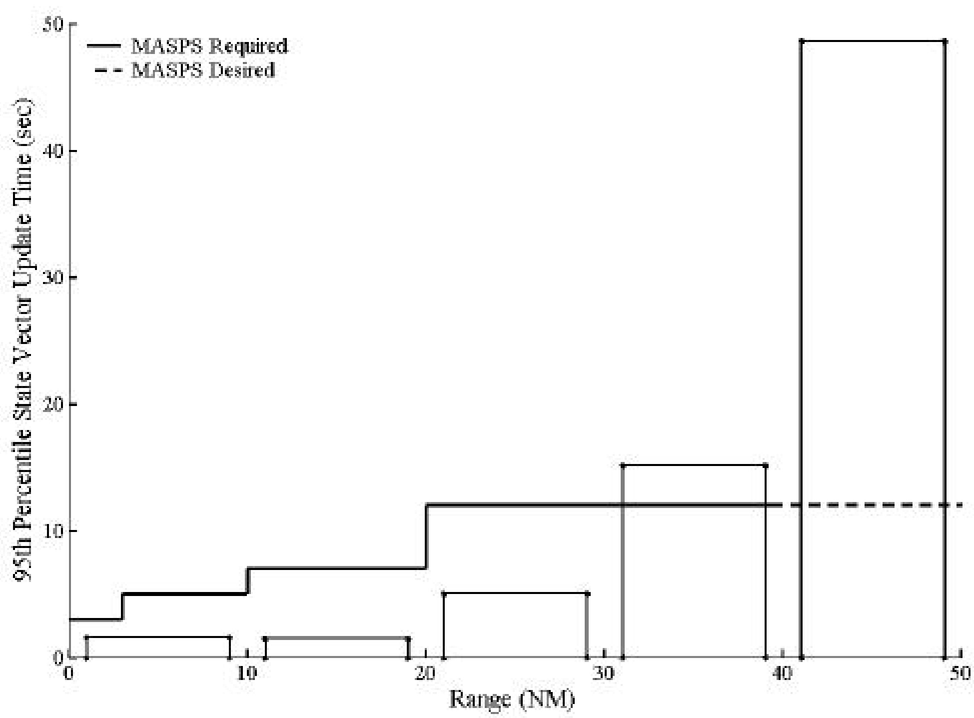

Figure P-12: 95-95 State Vector Update Rate for A2-to-A2 Air-to-Air Reception in LA2020-[24k]

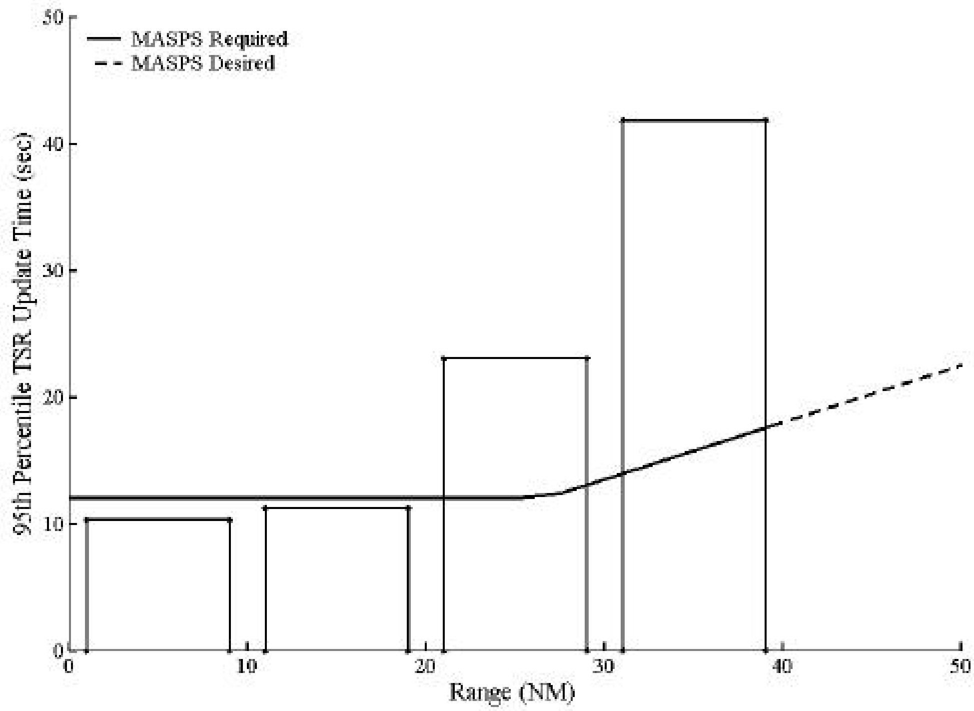

Figure P-13: 95-95 TSR Update Rate for A2-to-A2 Air-to-Air Reception in LA2020-[24k]

Recall that the LA 2020 scenario includes 2694 aircraft and 50 ground vehicles transmitting on 1090 ES. The results for LA 2020 shown in Figure P-2 through Figure P-13 are summarized in Table P-1. The values in the table are determined from the histograms by looking at the bars in the ten-mile bins and using the upper range for the last bin that is under the requirement line. For example, in Figure P-13 above, the ten-mile bar from 10-20 NM is the last bin under the requirement line, so the range for the 95-95 metric for A2-to-A2 TSR updates is 20 NM.

Table P-1: Air-to-Air 1090 ES Performance Relative to ADS-B MASPS (DO-242A)

Transmitter	Receiver	Mode A/C	Update Type	Range
A3	**A3**	24,000	SV	70 NM
			TSR	50 NM
A2	**A3**	24,000	SV	50 NM
			TSR	20 NM
A3	**A3**	30,000	SV	60 NM
			TSR	40 NM
A2	**A3**	30,000	SV	40 NM
			TSR	20 NM
A3	**A2**	24,000	SV	40 NM
			TSR	20 NM
A2	**A2**	24,000	SV	30 NM
			TSR	20 NM

P.2.4 Low Density Scenario

P.2.4.1 Low Density Scenario Description

P.2.4.2 Low Density Results and Analysis

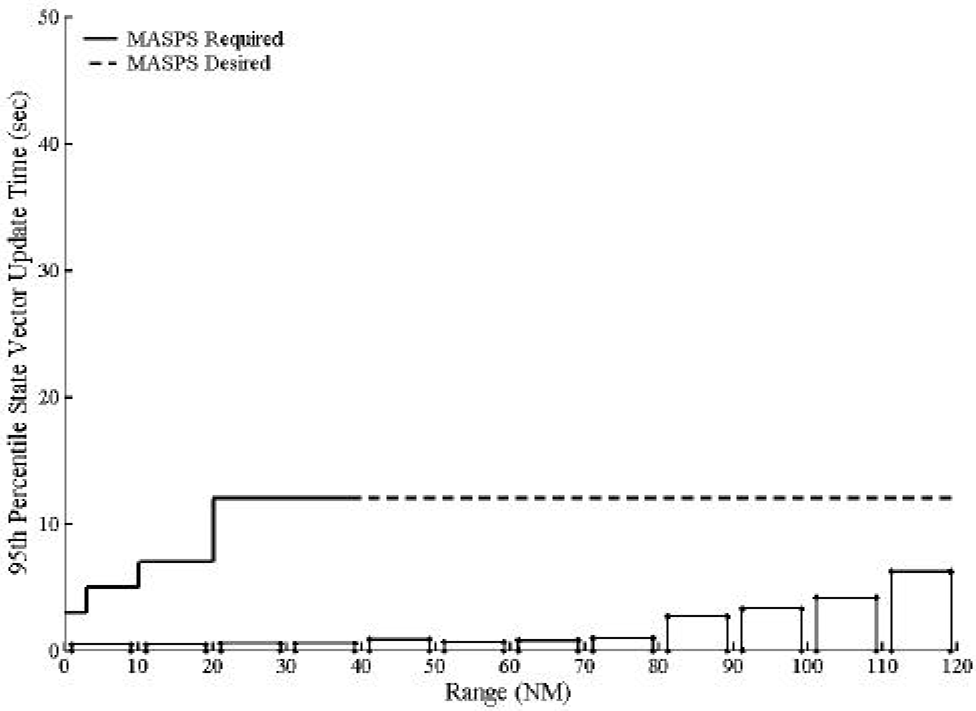

Figure P-14: 95-95 State Vector Update Rate for A3-to-A3 Air-to-Air Reception in 5,000 Mode A/C/Sec in the Low Density Scenario

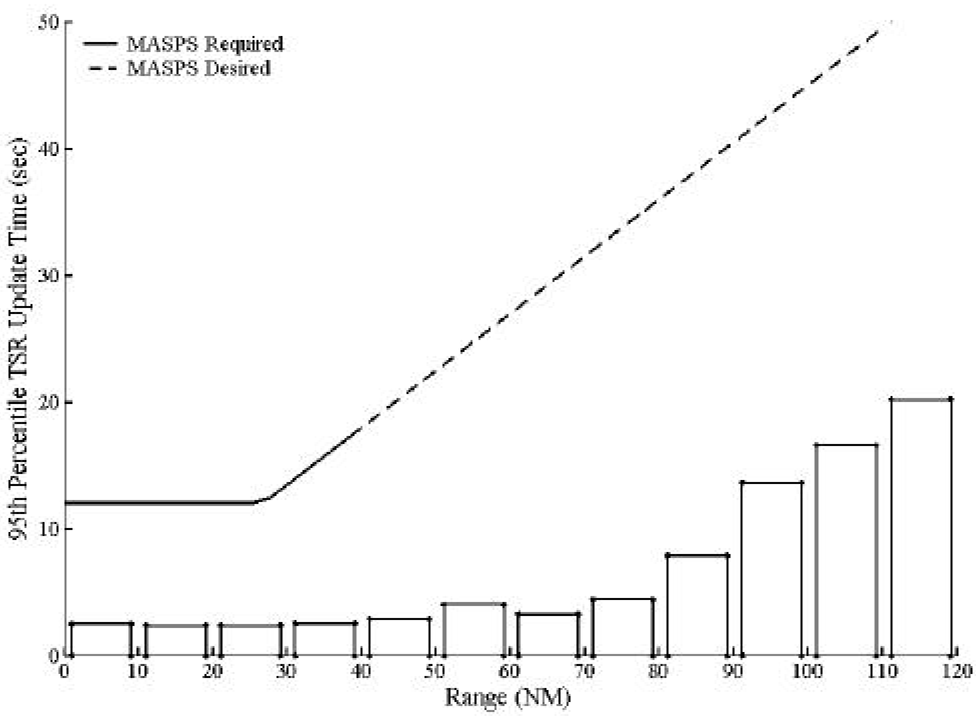

Figure P-15: 95-95 TSR Update Rate for A3-to-A3 Air-to-Air Reception in 5,000 Mode A/C/Sec in the Low Density Scenario

The results for the low-density scenario may be summarized as follows:

- ADS-B MASPS air-air requirements and desired criteria are met for state vector and TSR updates at all ranges specified by the ADS-B MASPS for the low density scenario.

P.2.5 Results and Conclusions

P.2.5.1 Considerations

The following considerations should be noted when interpreting the results of this analysis:

- The transmit power distribution for A3 transmitters, which was used for this analysis, was uniform from 53-56 dBm. These MOPS allow for A3 transmitters to extend as low as 51 dBm. This corresponds more closely to the transmit power distribution assumed for A2 class aircraft in this analysis; therefore, for a class A3 aircraft with a transmit power near the lower limit of the allowed range, it would be expected that performance would be given by A2 transmit results, rather than A3.
- The receiver performance model that was used for this analysis was based on average conformance with non-real-time simulation results provided by the FAA Technical Center and Lincoln Laboratory. Several manufacturer representatives have indicated that they felt that performance equivalent to that required by these MOPS was achievable. Still, there has been no testing of performance on MOPS-compliant equipment, and until this is done the receiver performance model has not been validated and remains hypothetical. In addition, the receiver performance model thus derived was designed to match the average performance predicted by the simulation results discussed above. This was necessary due to time and resources constraints and may add some additional uncertainty to the results.
- The results of this study should not be directly compared with any analysis not described in this Appendix, without taking into account differences in assumptions and analysis techniques. For example, the 1090 ES analysis in the TLAT report assumed different transmit power distributions, receiver decode performance, and Mode A/C interference levels, so it is not surprising that the results of that study differ from those reported here.
- Finally, in evaluating expected performance through the use of simulations, it is important to be aware of the inherent uncertainties in results due to the indeterminate nature of the assumptions, as well as the uncertainties in the modeling process itself. This is true for performance predictions resulting from any type of simulation technique. For example, in this analysis it was assumed that the number of aircraft in the LA Basin would increase by 50% by the year 2020, that most aircraft would be Mode S equipped, that a number of TCAS improvements would be universally deployed, and that the A3 transmit power would be as described above. These assumptions all include associated uncertainty; modifying any of the assumptions could result in a change in predicted performance.

P.2.5.2 Summary

Keeping in mind the conditions described in the previous section, the performance of 1090 Extended Squitter in the two scenarios examined may be summarized as follows:

- In the LA 2020 high density air traffic scenario, this analysis concludes that A3 aircraft should be capable of participating with other A3 aircraft in the applications defined in DO-242A which require state vector and TSR for ranges up to and including 40 NM. For applications which require state vector only, the range is extended to 60-70 NM, depending on the interference environment.

- In the low density air traffic scenario, this analysis concludes that A3 aircraft should be capable of participating with other A3 aircraft in the applications defined in DO-242A which require state vector and TSR for all required and desired ranges.

- In the LA 2020 (24,000 Mode A/C) high density air traffic scenario, this analysis concludes that A3 aircraft should be capable of participating with A2 aircraft in the applications defined in DO-242A which require state vector only for ranges up to and including 40 NM. The exchange of TSR information is limited to 20 NM between A2 and A3 equipage aircraft.

- In the LA 2020 (24,000 Mode A/C) high density air traffic scenario, this analysis concludes that A2 aircraft should be capable of participating with A2 aircraft in the applications defined in DO-242A which require state vector only for ranges up to and including 30 NM. The exchange of TSR information is limited to 20 NM between A2 equipage aircraft.

- Neither A1 nor A0 equipage was evaluated for this analysis.

This analysis has not evaluated the effect of transmitting more detailed intent information, such as TCRs. Future MOPS revisions should consider modifying the transmit power requirement for A3 equipage, so that the minimum power corresponds to that assumed in this analysis. In addition, improved A2 performance could be achieved by modifying either or both of the MTL requirement and the enhanced decoding techniques used.